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UDENAR Campus Verde Initiative

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Abstract

The UDENAR Campus Verde Initiative is a project at Universidad de Nariño (Colombia) combining an electric bicycle fleet, a photovoltaic charging system, and a grid injection system of the unused energy for self-consumption. Members of the university use the electric bicycles for daily commuting. The bicycles use a photovoltaic charging system in a solar parking located on campus. The bikes charge while parking, taking advantage of the sunny hours. A grid injection system was implemented to better use the energy not supplied for charging from the photovoltaic solar panel array located on the roof of the bicycle parking space. A 12,5 kWp photovoltaic system and fleet of 60 bicycles are reducing estimated emissions by 6.38 Ton CO2 and 7.08 Ton CO2 respectively for each year of use.

Keywords: *Solar resources, sustainable transportation, e-movility*

1. Introduction

Alternative sources of energy are important topics in the agenda of most of governments and organizatiions (Cadoret and Padovano, 2016; Struntz et al., 2016). In particular, Nariño (in southwestern Columbia) has begun to develop projects as part of the “Sustainable Rural Energization Plan for the Department of Nariño 2013-2030” (Chavez et al., 2014). This plan develops a comprehensive energy and socioeconomic diagnosis of the rural sector, establishes localized energy policy guidelines, and proposes an innovative methodology for the formulation of economic, technical, environmental, and social sustainable projects using clean energy sources (CCEP USAID, 2014). Another project, the “Analysis of Energy Opportunities through Alternative Sources in Nariño,” includes identifying the feasibility of renewable sources such as biomass, wind, and solar in the region. Using this information (Pantoja et al., 2016), a feasible zone is chosen to design a solution using the local resources with a design for the energy management. As part of these efforts, we proposed the "Campus Verde Initiative", a project that aims to combine an electric bicycle fleet, a photovoltaic charge system in a bicycle parking, and a grid injection system. The bicycles use a photovoltaic charging system in a parking place located at the main university campus, which works while the students go to class, taking advantage of the sunny hours**.** We expect that this experience can be replicated in different villages in Colombia as part of the "Rural Electrification Plan" described in Colombian Peace Agreements.

2. Methods and Data

Previous projects (Pantoja et al., 2016) have developed solar, wind, biomass and hydro maps that allow us to design alternative energy solutions for any place in the Department of Nariño (Fig. 1). Shown here are processed and analysed information of satellite images used to characterize solar irradiance (Cabrera et al, 2016). A complete measurement campaign with weatherstations was performed to collect valid data for the project location. The average solar radiation for the proposed solution at the project location, the university campus (San Juan de Pasto), is over 231.5 W/m^2 and 5.2 sunshine hours per day as indicated (Fig 2.). This information is available at geoalternar.udenar.edu.co and alternar.udenar.edu.co.

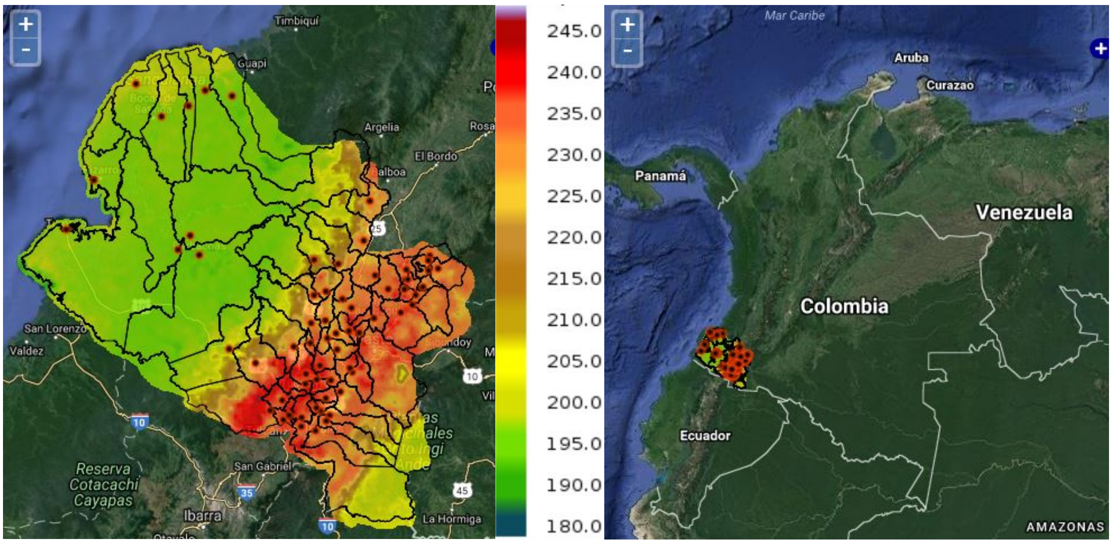

Fig. 1: Figure Solar map in Nariño State, Colombia (W/m2). Available in geoalternar.udenar.edu.co

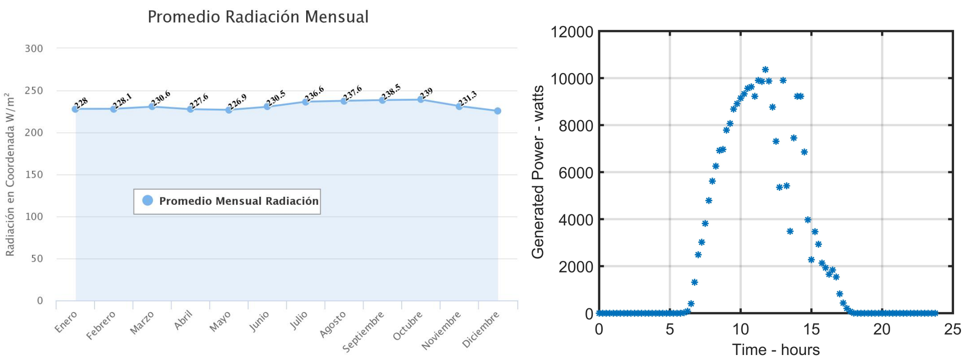

Fig. 2: (left) Annual radiation averages on Campus of Nariño University, (right) Average energy supplied by the PV system in one day

The specific project to reduce GHGs combines renewable energy and reduction in energy consumption. This involved implementing a photovoltaic charge system in a bicycle parking area. The 20x2 PV array was mounted over the bicycle parking. This covered 80 m^2 and can achieve 12.5 kW assuming performance ratio as 0.69 and constant STC temperature of 25 °C. A fleet of 60 electric bicycles was charged for 3 hours and reached consumption of 9.9 kW. Remaining energy is used in grid injection system.

The estimation for the avoided CO2 emissions using the fleet of 60 bicycles are described in Tables 1 and 2.

Table 1: Estimated fuel consumption avoided - two buses

Users Bicycles	No. of avoided Bus routes	Gallons of fuel per route (avoided)	Gallons of fuel per day (avoided)	Days of use per year
60	2	1	4	203

Table 2: Benefits per ton of CO2 avoided by lower consumption of fossil fuel

Gallons of fuel avoided per year	Estimated CO2 produced by each Diesel Gallon in Tons	Tons of CO2 avoided / Year	Tons of CO2 avoided /Month	Estimation (20 years)
812	0,008730265	7,08897518	0,590747932	141,7795036

Economical and social benefits for bike users is estimated to be U$250 per year, which is equivalent to a basic salary in Colombia and represents the average income of a person in a month.

The generation of clean energy through the photovoltaic system located on the roof of the parking lot of the bicycles and charging stations is given in Tables 3 and 4.

Table 3: Benefits by generated energy

Installed capacity (kW)	Sunshine hours per day	Generated energy per day (kWh)	Days of generation	Generated energy per year (MWh)
12,5	5,2	65	364	23,66

Table 4: Benefits by generated energy – equivalent CO2 Tons

Marginal Factor of Emissions Tons CO2/MWh	Performance ratio	CO2 Tons avoided /Year	Co2 Tons avoided /month	Estimation (20 years)
0,388	0,69	6,3801556	0,7566	127,603112

3. Conclusions

Solar generation and mobility energy use were combined as a strategic way to maximize CO2e reduction in a novel way. The proposed methodology could be duplicated in other areas and further enhance envirionmental and social sustainability in Colombia. Social benefits such as reduced cost in local transport enhance the benefits of this strategy.

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